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A NEW GENERIC ASSIGNMENT FOR *ARCHIPS FUMIFERANA* (CLEMENS), THE SPRUCE BUDWORM (LEPIDOPTERA, TORTRICIDAE) *

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For reasons which will be given in a forthcomng taxonomic paper, the spruce budworm, *Archips fumiferana* (Clem.), is here transferred to the genus *Choristoneura* Lederer, 1859, Wien Ent. Monatschr., 3:242. Genotype: *Tortrix rusticana* Treitschke, designated by Fernald, 1908, The genera of the Tortricidae and their types, p. 53. The transfer is made at present in order that this species may be properly referred to in a following paper dealing with its external anatomy.

THE EXTERNAL ANATOMY OF THE SPRUCE BUDWORM *CHORISTONEURA FUMIFERANA* (CLEM.). (LEPIDOPTERA, TORTRICIDAE) †

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This study was undertaken as a preliminary to a taxonomic revision of the North American species of the tortricid subfamily Archipinae.

The details of structure, as outlined for this common and economically important species, may be considered as representative of the group. In plan, this paper follows generally that of Madden's work (1944) dealing with the external anatomy of the sphingid *Protoparce sexta* John. The write wishes to acknowledge the constructive criticism and interest evinced by Dr. E. M. Walker.

THE HEAD AND ITS APPENDAGES

Head capsule (figs. 1-3). In the anterior aspect, the most prominent sclerite is the frons (*F*). This sclerite is broad throughout, slightly compressed laterally where it is bounded by the ocular sutures (*OS*) which extend from the antennal sockets ventrally to the subgenal region. An indistinct frontal suture (*FS*), between the antennal sockets, separates the frons from the vertex (*V*). The ventral margin of the frons is delimited by an obscure suture between the frontal pits (*P*). This suture separates the frons from the lunate clypeus (*C*).

The vertex (*V*) is a large, somewhat convex sclerite occupying the dorsofrontal portion of the head capsule. An indication of the coronal suture may be represented by a thin median area devoid of scale scars, extending from the frontal suture to the top of the head. The lateral ocellus (*O*) is located behind the antennal socket and dorsad to the compound eye.

The occiput (*OP*) extends from a curved suture between the ocelli, mark-

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ing the anterior margin, to the occipital foramen (*OF*) and is bounded laterally by the postgenae (*PG*). The postoccipital sclerite (*PO*) is produced ventrally into a triangular point of articulation with the distal apices of the lateral cervical sclerites. The lateral margins of the postgenae are extended to form the hypostomal bridge (*HB*).

The compound eyes (*E*) are subglobular and prominent laterally. The antennal sutures (*AS*) extend to the inner dorsal margins of the eyes and articulate with the antennal sclerites (*AC*), which appear firmly attached, at least inwardly, to the antennal scape (*SP*).

Each antenna consists of 46 segments. The scape (figs. 1, 2, *SP*) is bluntly clavate, slightly curved and much larger than the rest of the segments. The pedicle (*PD*) is only slightly larger than the rest of the short cylindrical segments.

Mouthparts (figs. 1-3). The labrum lies behind the clypeus and consists of a median lobe representing the epipharynx (*EP*) and two prominent lateral lobes which are apically pectinate with bristles and termed the pilifers. (*PF*). Behind each pilifer is situated a small apparently functionless sclerite which represents the mandible (*MD*). The maxilla (fig. 2a) consists of the galea (*GA*) or proboscis, the cardo (*CD*) and the stipes (fig. 2, *ST*) which bears the small, membranous, three-jointed, maxillary palpus (*MP*). Each galea bears a groove on its inner edge and paired teeth along the apical half of its outer edge. The base of this groove articulates with the sclerotized inner margin of the stipes which in turn articulates with the small, narrow, curved cardo, the base of which lies laterad to the labium and is concealed beneath the postgenae. The labial palpi (*LP*) are large and each consists of three segments. The basal segment is thick and slightly clavate and arises near the outer margin of the labium. The second segment is very long and slightly curved upward and the third or terminal segment is small and oblong.

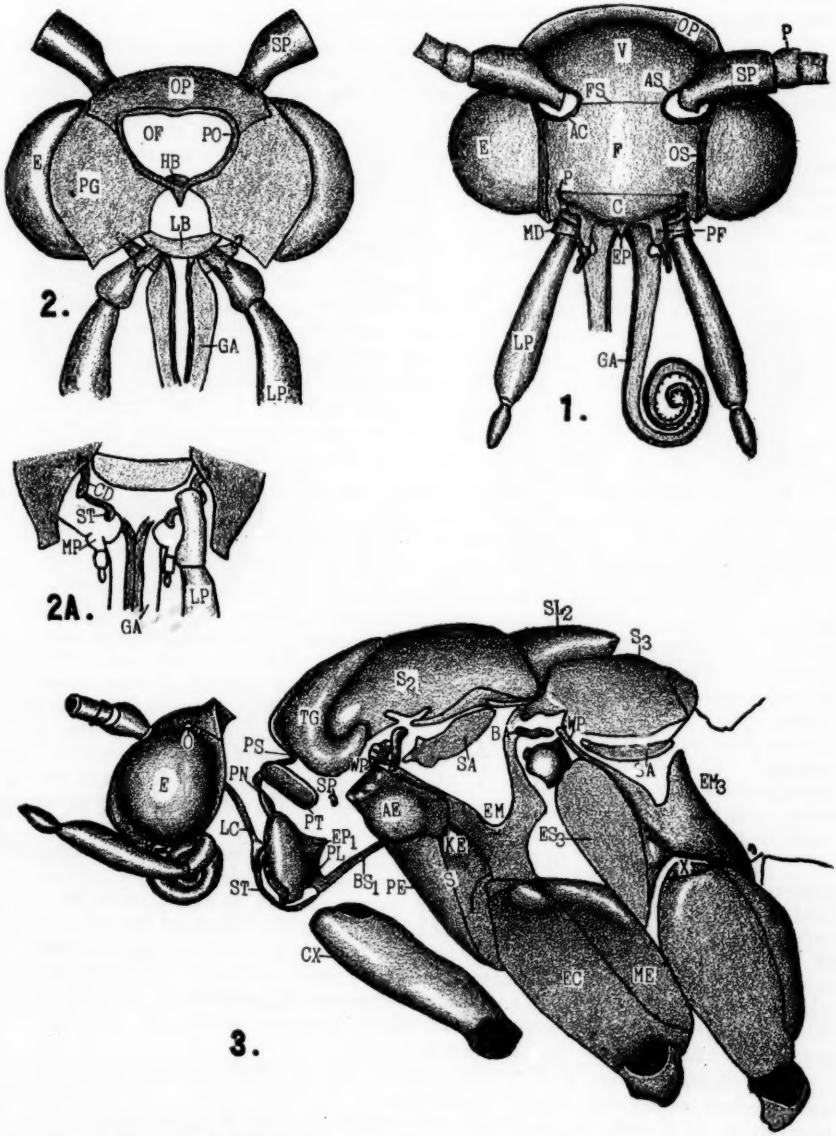
THE THORAX AND ITS APPENDAGES

Cervix (fig. 3, 5). The cervix constitutes that region between the head and thorax. It is mainly membranous except for a pair of "Y" shaped sclerites, the lateral cervical sclerites (*LC*). The stem of the "Y" articulates with the anterior margin of the prothoracic episternum. The posterior apices of the cervical sclerites lie dorsad to the anterior edge of the prothoracic sternum (*ST*), and the anterior apices articulate with the ventral margin of the postoccipital sclerite.

Prothorax (figs. 3-5). The pronotum (*PN*) is divided into three distinct parts and like the cervix is "Y" shaped. The proximal portion, representing the stem of the "Y", articulates with the anterior margin of the aborted mesothoracic prescutum and is separated from the broader arms by a pair of small subtriangular sclerites. The broad arms curve around the dorsal portion of the anterior opening into the thorax and articulate ventrally with the dorsal apices of the episternal sclerites (EP_1). The patagia (*PT*) consists of two membranous lobes lying dorsad to the broad arms of the pronotum.

The episternum (EP_1) is oblong-ovate and convex. Its dorsal apex articulates with the ventral margin of the pronotum and the ventral posterior margin articulates with the lunate pleuron (*PL*) which fuses with the posterior portion of the sternum (*ST*). The episternum is fused laterally with a narrow precoxale (*PR*) which fuses with the anterior portion of the sternum and delimits the front of the coxal cavity. The basisternum (BS_1) extends upward and backward. It is narrow with bifurcate apices, anteriorly articulating with the posterior margin of the pleuron and posteriorly with the bifurcate arms of the anterior edge of the spinasternum (*SS*). The latter sclerite is strap-like with bifurcate apices and extends downward and backward to articulate with the anterior margins of the mesothoracic basisternum.

PLATE III



External Anatomy of *Choristoneura fumiferana* (Clem.)

Fig. 1. Anterior view of head.
Fig. 2. Posterior view of head.
Fig. 2A. Posterior view of mouth parts.
Fig. 3. Lateral view of head and thorax.

Mesothorax (figs. 3-5). The prescutum (*PS*) is a narrow strap-like sclerite along the anterior margin of the scutum. Because of the overturn of this portion of the scutum it is hidden in the dorsal aspect and can be seen to best advantage in a ventro-lateral anterior view.

The scutum (S_2) is the most prominent of all the dorsal sclerites. Dorsally, it is somewhat hexagonal and convex. Each lateral margin is produced into a suralare (*SU*) which serves as the anterior fulcrum for wing movement.

The irregularly shaped subtegula (*SB*) lies in front of the suralare. Its anterior portion is directed into a lateral concavity of the margin of the scutum, and the posterior portion is directed backward to the pleural wing process. Attached to the subtegula is the large lunate tegula (*TG*) which extends dorsolaterally over the anterior portion of the scutum. The ventral margin is produced posteriorly to extend beneath the base of the fore wing.

Behind the suralare the lateral margin is produced into a forward projecting lobe the adnotale (*AL*) which articulates with the 1st axillary wing sclerite. Behind the adnotale is a longer projection of the scutum termed the adanale (*A*) and behind this a shorter projection, the postadanale (*PA*). The adanale articulates with the proximal end of the third wing axillary.

The scutellum (SL_2) lies caudad to the scutum. It is arcuate anteriorly, angled behind and extended laterally into the membranous axillary cord (*AX*) which adjoins the posterior margin of the fore wing.

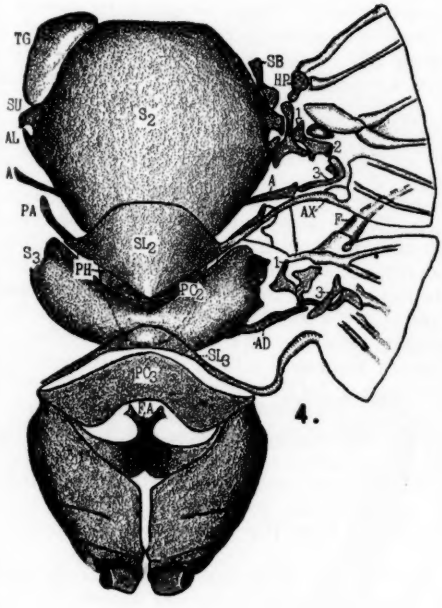
The postscutellum (PC_2) is a short narrow sclerite partially concealed between the scutellum and the metathoracic scutum. The intersegmental membrane between these two latter sclerites, forms a large backward and inwardly projecting, spatulate-like sclerotic structure, the postphragna (*PH*).

The pleuron (fig. 3) is divided vertically by an angled suture into an anterior portion, the episternum, and a posterior portion, the epimeron (*EM*). The episternum is horizontally divided by a curved suture into a dorsal anepisternum (*AE*) and a ventral katepisternum (*KE*). The preepisternum (*PE*) is largely membranous and is separated from the katepisternum by the preepisternal suture (*S*). The epimeron (*EM*) is "V" shaped. The anterior arm extends to the pleural wing process (*WP*) and the posterior arm extends to the postadanale. The subalare (*SA*) is an irregular, sclerotized plate, situated in the membrane above the epimeron. It functions as an attachment for some of the wing muscles. The mesothoracic spiracle (fig. 3, *SP*) lies in the membrane anterior to the anepisternum.

The basisternum (BS_2, fig. 5) is a large triangular sclerite invaginated longitudinally to form a mid-ventral suture and produced inwardly to form a keel-like ridge. The furcasternum (FS_2) is represented by two narrow sclerites arising from the posterior apex of the basisternum and extends to the inner edge of the coxae where they are invaginated to form a pair of strongly sclerotized arms which extend into the thoracic cavity to unite with a strong inner bridge which extends on either side to adjoin the posterior portion of the epimeron. This structure apparently supports the whole thoracic region and occupies the area at the caudal end of the mesothoracic cavity.

Metathorax (figs. 3–5). The scutum (S_3) is somewhat hour-glass-shaped and overlaid posteriorly by the metathoracic scutellum (SL_3). It is projected laterally at its middle to form the pivot point of hind wing articulation with the 1st axillary and behind the middle again projected into a long, narrow adanale (*AD*). The scutellum (SL_3) is a long cresent-shaped sclerite, the lateral margins of which are produced into the membranous axillary cord, extending as in the fore wing to the anal region. The postscutellum (PC_3) lies immediately caudad of the scutellum. It gives rise to a large, folded, internal phragma.

PLATE IV



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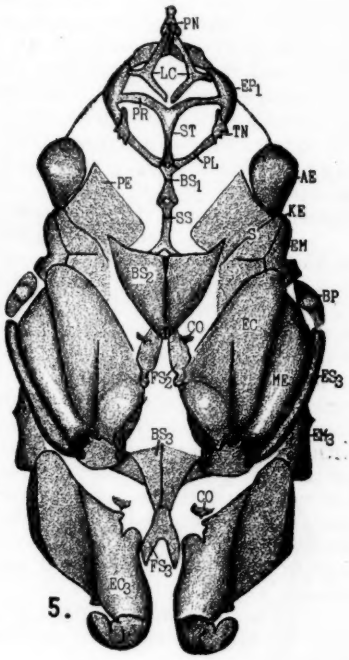

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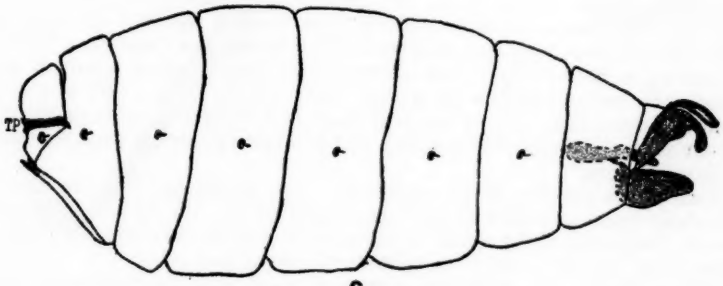

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External Anatomy of *Choristoneura fumiferana* (Clem.)

Fig. 4. Dorsal view of thorax.
Fig. 5. Ventral view of thorax.
Fig. 6. Lateral view of abdomen.

The metapleuron (fig. 3) is divided vertically as the mesopleuron into an anterior episternum (ES_3) and a posterior epimeron (EM_3). The episternum extends ventrally to the basisternum and at its anterior-dorsal margin is a subcircular, convex sclerite, the basalare pad (*BP* fig. 5). The metathoracic spiracle lies beneath the anterior margin of this pad. Dorsal to the pad is an elongate basalare (*BA*). The anterior arm is produced into a long, pleural wing process (*WP*) and the oblong subalare (*SA*) lies in the membrane dorsal to its deeply excavated upper margin. The basisternum (BS_3, fig. 5) is inwardly keeled as in the mesothoracic basisternum and presents a midventral line. It is produced caudally to form the furcasternum (FS_3) the apices of which articulate with the inner face of the eucoxa (EC_3) and the apophyses from which extend dorsally to form the furcal arm (*FA*, fig. 4) and continue laterally to the region behind the dorsal posterior margin of the epimeron.

Legs (figs. 3 and 5, 6-8). The prothoracic coxa (*CX*) is slightly flattened laterally, broadest near the base and gradually curving along the anterior margin to a narrower distal apex. It articulates basally with the narrow trochantin (*TN*). The coxae of the meso- and metathorax are more or less firmly attached to the pleura but have points of articulation on their inner faces with the apices of the furcasternum, and again further anteriorly a condyle (*CO*) articulates with an arcuate sclerotic portion of the membrane between the coxae and the basisternum. They are divided by a longitudinal basicostal suture into an anterior portion the eucoxa (*EC*) and a posterior meron (*ME*). Distally they articulate with the condyles of the trochanter. Laterally at the dorsal margin is a triangular sclerite (*X*) which may be homologous with the prothoracic trochantin. It has been termed the epicoxal piece by some authors. Ventrally (fig. 5) the eucoxa is longitudinally divided and dorsally the meron is partially divided horizontally. It is possible that these represent an invagination of the coxal wall to function as additional support, rather than the remnant of a definite suture.

The trochanters (*TR*) of all the legs are irregular rings, articulating with the apex of the coxae and firmly attached to the proximal apices of the femora.

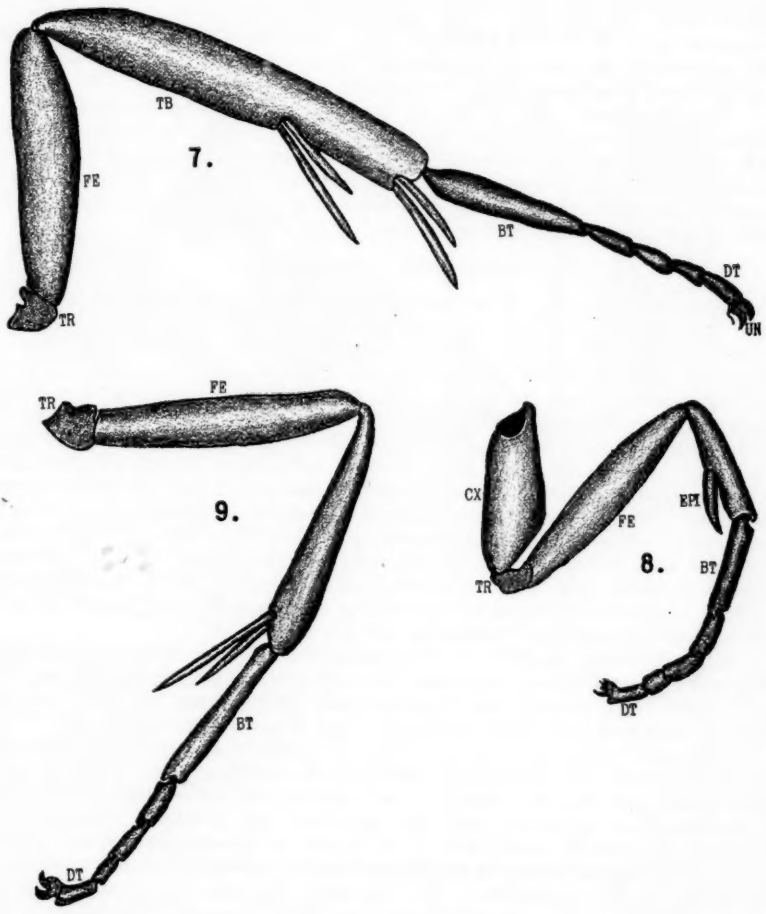
The femora (*FE*) of all the legs possess slightly convex posterior margins. The anterior margins of the meso- and metathoracic femora are straight while those of the prothoracic ones are convex. The tibia of the fore leg (fig. 8) is short and bears a stout claw-like epiphysis (*EPI*) on its inner margin. The tibia of the mid leg is clavate (fig. 9) and bears on its inner margin, a pair of apical spurs, the outer one of which is the longer. The tubular tibia (*TB*) of the hind leg is much larger than that of the other legs and bears two pairs of spurs, an apical pair as on the tibia of the mid leg, and another pair just beyond the middle of the inner margin.

Each tarsus consists of five segments. The basitarsus (*BT*) or first segment is about equal in length to the total length of the apical four. The apical segment or distitarsus (*DT*) bears, at the apex, a pair of sickle-shaped claws, the unguifers (*UN*) between which arises a membranous pad.

Wings (figs. 4, 10). The fore wings are broad with the costa more strongly convex toward the base and with the outer margin broadly rounded. The hind wings are as broad as the fore wings but the outer margin is more pointed and more gradually curved from the apex to the anal region.

The wing venation as shown in the figures is based upon the Comstock-Needham system. As in most Lepidoptera, the base of medius in both wings has been lost for the length of the discal cell. Another characteristic common to both wings is the loss of the main portion of the first anal, the base of which forms a fork with the base of the second anal and the distal portion of which is preserved at the outer margin. The fore wing possesses ten veins exclusive of the costal and anal ones and the third anal is lost. The hind wing has seven veins (likewise exclusive of the costa and anals) and the third anal is preserved.

PLATE V



External Anatomy of *Choristoneura fumiferana* (Clem.)

Fig. 7. Hind leg.
Fig. 8. Foreleg.
Fig. 9. Middle leg.

The wings are attached to the thorax by membranes containing the irregularly shaped axillary sclerites of articulation (fig. 4). The humeral plate (*HP*) articulates with the base of the costa of the fore wing. The first axillary (1) lies behind the humeral plate and articulates anteriorly with the apex of the suralare, outwardly with the base of the subcosta and the second axillary (2) and inwardly with the adnotale. The second axillary articulates posteriorly with the anterior apex of the third axillary (3). This latter sclerite angles inwardly to articulate with the apex of the adanale. The sclerites of articulation are similar in the hind wing except that the humeral plate is absent.

The frenulum (figs. 4, 10, *F*) is directed obliquely forward from the humeral angle of the hind wing. In the male it consists of a single stout spine which extends along the underside of the fore wing to engage a flat sclerotized frenulum hook, situated between the costa and subcosta veins. In the female the frenulum is divided into a group of bristles, the apices of which engage a hair cluster or retinaculum situated at the base of the cubital vein.

THE ABDOMEN AND GENITALIA.

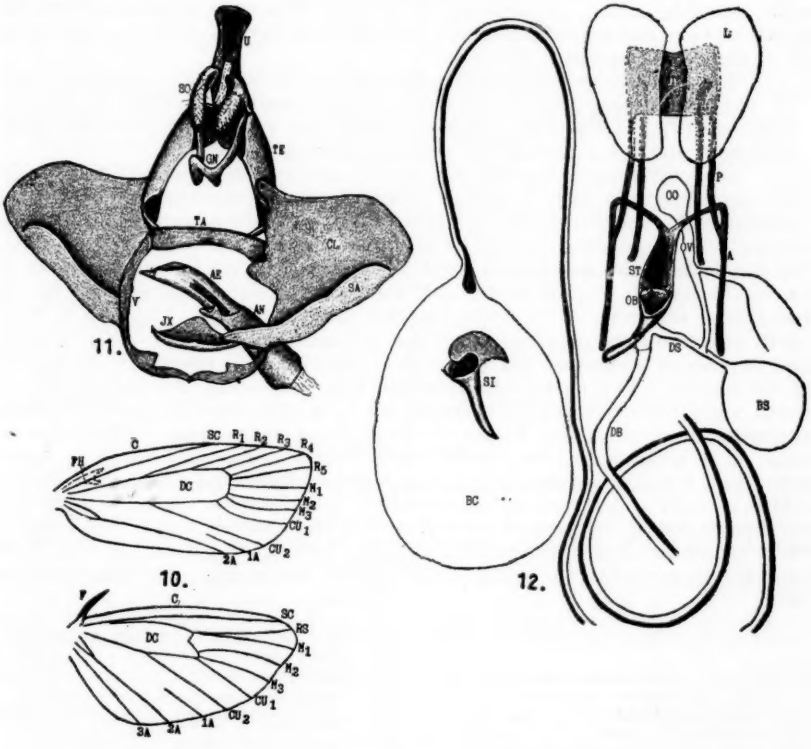
The *abdomen* (fig. 6) is largely membranous and composed of ten segments, the last two of which are modified to form the male genitalia, and the last three to form the female genitalia. Segments one through seven bear the abdominal spiracles in the pleural region. Each segment is joined by a conjunctival membrane and the posterior margin of each segment overlaps to some extent, the anterior margin of the following one. The first segment is more complex in structure than those immediately following. The tergite is represented by a faintly sclerotized plate with strongly sclerotized lateral margins which extend forward and fuse with the posterior margin of the metathoracic postscutellum. These lateral margins contain a deep longitudinal groove which is considered to represent the tergo-pleural groove (*TP*). The sternal region of the second abdominal segment is produced anteriorly and laterally sclerotized to form a bifurcate point of attachment with the thorax. With the exception of the above sclerotized portions, the remaining intersegmental regions of these and those segments immediately following, are not well defined.

Male Genitalia (fig. 11). These structures are derived from the modified ninth and tenth abdominal segments. Zander (1903), Beirne (1942), and Rakshpal (1944) have studied the embryological development of these structures and have shown in part, their derivatives and female homologues.

The *ninth segment* comprises the main parts of the genitalia. The tegumen (*TE*) is well developed and represents the ninth tergite. It forms an inverted V-like roof over the genitalia, each arm of the tegumen extending laterally downward to articulate with the apices of the U-shaped vinculum (*V*). This latter structure is considered to be merely a sclerotization of the intersegmental membrane between the eighth and ninth segments, but the evidence for such a view is not conclusive. The vinculum has also been considered as a derivative of the ninth sternite but the juxta (*JX*) appears to represent a more convincing homology. It takes the form of a subtriangular plate situated ventrally with respect to the rest of the parts, and articulates laterally with the bases of the claspers (*CL*). These latter structures are the chief clasping organs of the male and are extremely important taxonomically. They take the form of a pair of large, flattened, double-walled lobes, slightly tapering and blunty pointed apically. The area along the lower margin of each clasper is more heavily sclerotized and differentiated from the rest of the clasper by an apparent extension and inward folding of the ventral margin. This area is termed the sacculus (*SA*). Inwardly the base of the clasper is produced to form a dorsal and a median lobe. These bases articulate ventrally with the juxta, mesally with the upper portions of the vinculum and dorsally with the lateral margins of the transtilla (*TA*). This latter structure is in the form of a bridge, connecting the upper bases of the claspers near the articulation of the tegumen and vinculum. The claspers

appear to be derivatives of the gonapods of the ninth abdominal segment. The derivation of the transtilla is obscure.

The anellus (*AN*) is a tube around the base of the aedeagus (*AE*). It lies immediately dorsal to the juxta and its ventral margin is produced into a bifurcate apex which articulates with the anterior apex of the juxta. The aedeagus is a tubular continuation of the anellus extending posteriorly through the vincular ring. It is produced ventrally into a long tooth.



External Anatomy of *Choristoneura fumiferana* (Clem.)

Fig. 10. Wing venation.
Fig. 11. Male genitalia.
Fig. 12. Female genitalia.

The *tenth and eleventh segments.* The uncus (*U*) is a prominent dorsal terminal structure. It articulates basally with the posterior margin of the tegumen and is in the form of a downward curving spoon. Forbes (1939) concludes that its basal portion at least represents the tenth segment. The gnathos (*GN*) is in the form of a pair of arms arising from near the ventral base of the uncus and each arm is divided into two portions—a basal short triangular part and a distal curved blade-like part. The apices of the two arms are flattened and fused, to form a broad hook in the mid-ventral line. This hook may represent the tenth sternum. The socii (*SO*) are paired membranous lobes, arising near the ventral base of the uncus and attached to the basal portion of the arms of

the gnathos. They are probably homologous with the anal prolegs of the larva and, as Forbes pointed out, may belong to the eleventh segment. The anus is supported on either side by the arms of the gnathos and protrudes between the socii.

Female Genitalia (fig. 12). The *tenth segment* is represented by a pair of hairy membranous lobes, the ovipositor lobes (*L*). These are situated at the extreme apex of the abdomen, one on either side of the anal and oviducal openings. They represent the tenth tergum (Kusnezov 1917) and are homologous with the male uncus. A pair of long heavily sclerotized rods arise from their dorsal surfaces and extend anteriorly into the body cavity. The lobes are attached to the ninth tergum.

The *ninth segment* is represented by a well developed plate-like tergum (*T*) the lateral margins of which are produced anteriorly to form the posterior apophyses (*P*). These are rod-like in form and apparently serve for muscle attachment and for stiffening the abdomen during oviposition.

The *eighth segment* is the one mainly modified to function in copulation. The eighth sternum (*ST*) is highly modified and presents characters often used taxonomically. In this species it is trough-like, with the ostium bursae opening, ventrally at its anterior end. The posterior margins are produced laterally to the dorso-lateral line where they curve forward and extend for some distance just under the seventh tergum, fusing with the apices of the posterior apophyses and continuing anteriorly to form the anterior apophyses (*A*). The ostium bursae (*OB*) represents the opening of the ductus bursae (*DB*). The latter is heavily and irregularly sclerotized just before the opening and is referred to as the neck of the ostium. The ductus bursae is the tube connecting the ostium with the bursa copulatrix (*BC*) and is strengthened by a long, heavily sclerotized ribbon extending from the bursa almost to the neck of the ostium. The bursa is a large, oval membranous sac, which bears inwardly, near its base, a heavily sclerotized hornlike signum (*SI*). This latter structure has a bulbous base from which extends a short lateral sclerotization. The ductus seminalis (*DS*) joins the ductus bursae at the neck of the ostium and extends into a blind sac, the bulla seminalis (*BS*). Before reaching the neck of the blind sac, the ductus branches to extend to the oviduct (*OV*) which opens into the ostium oviductus (*OO*).

SYNOPTIC TABLE OF ABBREVIATIONS APPLIED TO THE EXTERNAL ANATOMY

A (fig. 4) Mesothoracic adanle
A (fig. 12) Anterior apophyses
AC Antennal sclerite
AD Metathoracic adanale
AE (figs. 3, 5) Anepisternum
AE (fig. 11) Aedeagus
AL Adnotale
AN Anellus
AS Antennal suture
AX Axillary cord
BA Basalare
BC Bursa copulatrix
BP Basalare pad
BS Bulla seminalis
BS_1 Prothoracic basisternum
BS_2 Mesothoracic basisternum
BS_3 Metathoracic basisternum
BT Basitarsus
C Clypeus
CD Cardo
CL Clasper
CO Condyle
CX Prothoracic coxa
DB Ductus bursae
DS Ductus seminalis
DT Distitarsus
E Compound eye
EC_2 Mesothoracic eucoxa
EC_3 Metathoracic eucoxa
EM Mesothoracic epimeron
EM_3 Metathoracic epimeron
EP Epipharynx
EP_1 Episternum
EPI Epiphysis
ES_3 Metathoracic episternum
F (fig. 1) Frons
F (fig. 4, 10) Frenulum
FA Furcal arms
FE Femur
FS Frontal suture
FS_2 Mesothoracic furcasternum
FS_3 Metathoracic furcasternum
GA Galea
GN Gnathos
HB Hypostomal bridge
HP Humeral plate
JX Juxta
KE Katepisternum

L Ovipositor lobe
LB Labrum
LC Lateral cervical sclerites
LP Labial palpus
MD Mandible
ME Meron
MP Maxillary palpus
O Ocellus
OB Ostium bursae
OF Occipital foramen
OO Ostium oviductus
OP Occiput
OS Ocular suture
OV Oviduct
P (Fig. 1) Frontal pit
P (fig. 12) Posterior apophyses
PA Postadanale
PC_2 Mesothoracic postcutellum
PC_3 Metathoracic postscutellum
PD Pedicle
PE Preepisternum
PF Pilifer
PG Postgena
PH Postphragma
PL Pleuron
PN Pronotum
PO Postoccipital sclerite
PR Precoxale
PS Prescutum
PT Patagium
S Preepisternal suture
S_2 Mesoscutum
S_3 Metascutum
SA (fig. 3) Subalare
SA (fig. 11) Sacculus
SB Subtegula
SI Signum
SI_2 Mesothoracic scutellum
SL_3 Metathoracic scutellum
SO Socius
SP (figs. 1, 2) Scape
SP (fig. 3) Spiracle
SS Spinasternum
ST (fig. 2) Stipes
ST (figs. 3, 12) Sternum
SU Suralare
T Tergum
TA Transtilla
TB Tibia
TE Tegumen
TG Tegula
TN Trochantin
TP Tergo-pleural groove
TR Trochanter
U Uncus
UN Unguifers
V (fig. 1) Vertex
V (fig. 11) Vinculum
WP Wing Process
X Metathoracic epicoxal piece

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THE MALE OF *DIACHLORUS FERRUGATUS* (FABR.) (DIPTERA, TABANIDAE) *

BY G. E. SHEWELL

Ottawa, Ont.

A male of *Diachlorus ferrugatus* (Fabr.) was recently captured at London, Ontario, by Mr. F. J. Hudson, an inspector for the Plant Protection Division, Science Service, of the Dominion Department of Agriculture. The specimen was taken during inspection of a case of *Peperomia* imported from the John's Nurseries, Apopka, Florida. As this seems to be the first recorded capture of this sex of the species, the following description of the specimen is offered. The Canadian National Collection contains two females, in poor condition, from Ellis Lake, Havelock, N.C., and these specimens together with Stone's** description of the female have been utilized for purposes of comparison.

Diachlorus ferrugatus (F.)

Male. Length, excluding antennae, 9.5 mm. Broadly holoptic as in typical *Tabanus*. Eyes bare, uniform dark brown, without trace of banding even when relaxed, the surface slightly flattened above, not greatly inflated, outline of head capsule much as in the female. Eye facets enlarged above, the rather gradual transition from large to small facets occurring just below the greatest width of the eye, most noticeable centrally, but not forming an abrupt line of demarcation. Small facets occupying little more than lower half in occipital region, remainder of occiput margined by medium-sized or large facets. Vertex and upper occiput deeply and narrowly cleft, the minute ocellar tubercle completely sunken within the cleft and remote from contact with the eyes; ocelli absent; occiput on either side of cleft not visible from above. Frontal triangle small, not greatly attenuated dorsally, with a transverse depression, above which it is slightly raised above level of eye margins. Genae with a rather noticeable tuft of black hairs at the lowest part of the eye and scattered black hairs up to the antennal pit, hairs otherwise pale golden. (In the females before me, only the lower tufts of black hairs are present). Antennae as in the female, but the hairing longer with more black hairs dorsally on the basal two segments. Basal portion of third segment darkened towards apex on outer side, apical portion entirely black. Second palpal segment one-third shorter than in female, slightly inflated, the bluntly pointed tip with a rather dense tuft of black hairs. Labella deep black. Theca yellow.

In general habitus, the specimen resembles the other sex closely, except for the following points which seem to merit attention. There is a narrow hyaline streak in cell R_3, partially splitting the apical cloud of the wing. It is very faintly suggested in one of my females but not in the other. The fore femora are noticeably blackened on about the apical third, a character noted by Osten-Sacken† but not by Stone. It is present to a less extent in my females. The black hairs on dorsal and posterior surfaces of hind tibiae are longer and denser. The abdomen is noticeably more tapering, fifth and sixth tergites broadly brown laterally, leaving the recurved sides, the posterior margin and a central stripe yellow; seventh tergite, sixth and seventh sternites brown with yellow hind margins; seventh sternite more than twice length of visible portion of its tergite; genitalia brownish yellow, small; all hairs on seventh segment and genitalia black.

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*Contribution No. 2471, Division of Entomology, Science Service, Department of Agriculture, Ottawa.

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LOW TEMPERATURE AS A FACTOR IN THE MORTALITY OF EGGS OF *MANTIS RELIGIOSA* L.*

BY R. W. SALT AND H. G. JAMES

Lethbridge, Alta., and Belleville, Ont.

INTRODUCTION

In the district around Belleville, Ontario, the eggs of *Mantis religiosa* are deposited during the end of August and throughout September. Some embryonic growth occurs after the eggs are laid and before they enter diapause for the winter. Many of the eggs which have over-wintered, however, fail to continue their development so that the percentage of hatch in the following spring is often greatly reduced. This egg mortality varies from year to year. Records obtained between 1940 and 1946 by the dissection and incubation of current oothecae collected at the end of March have indicated mortalities ranging from 15.6 to 86.4 per cent. Such mortality has been generally attributed to low winter temperatures although there was also evidence that eggs could be exposed to a temperature as low as—20°C without injury.

It was felt, therefore, that more precise information on the effect of low temperatures on the eggs was desirable, and in 1945 a cooperative project was arranged to investigate this aspect of the problem. The experimental work involving the use of low temperature apparatus was conducted at Lethbridge, Alberta, while the observational studies were carried on at Belleville, Ontario.

MATERIAL AND METHODS

Mantis eggs were collected weekly at points near Belleville and were sent to Lethbridge by air mail on the day of collection. Oviposition began later than expected, the first shipment being sent on September 7, 1945, instead of on August 21, as planned.

The oothecae were kept at room temperature until frozen, which in most cases was not long after receipt. This treatment had no apparent effect on the undercooling points. The embryos normally go into diapause at an early gastrula stage and the majority were undoubtedly in diapause when frozen.

Eggs could not be frozen individually, as it was found to be impossible to remove them from the oothecae without harm. The outer lamellate covering of the ootheca was removed and the pod cut into two pieces. One piece was retained as a control and the other piece was frozen. The technique used in freezing, involving continuous temperature readings, has already been described by Salt (1936). Since each piece of ootheca contained many eggs, multiple undercooling points were recorded. Only a few eggs were situated adjacent to the thermocouple itself, most of them being separated from it by distances up to half an inch. This introduced a small error, for practical purposes negligible. The thermocouple of course records only its own temperature (indirectly; actually the galvanometer deflection is proportional to the e.m.f. flowing through the couple which in turn is proportional to the temperature, within limits). If an egg freezes and liberates heat of fusion, and another egg does the same a second or two later, there is a blending of effects at the thermocouple. The second egg was probably slightly colder at its undercooling point than the thermocouple actually recorded, since the heat from the first egg would not have been entirely dissipated in so short a time. The heat of fusion is of course radiated, conducted and even convected away from its source, the egg, and the environment is warmed by it, roughly in proportion to its conductivity and its distance from the source. Since the second egg as well as the thermocouple receives some of this heat, it is not likely that their temperature differential could be very great. The error is almost certainly less than 0.1°C. and can be safely ignored.

*Contribution No. 2466, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

EXPERIMENTAL RESULTS

The first five oothecae were received on September 10, 1945, and the first eggs were frozen the following day. The freezing chamber had a minimum temperature of about −30°C., which was soon found to be too high to include the full undercooling range of the eggs. Dry ice was obtained for further work, but in the meantime these five oothecae were frozen insofar as the freezer permitted. The undercooling points ranged from −23.7°C. down, only a few being higher than −26°C. One ootheca was soaked in water for 24 hours before freezing. Water had entered the spaces between the lamellae of the outer pod, but the inner pod and lamellae themselves did not appear to be absorbent. A small amount of water was left on the pod when it was frozen, but the undercooling points were not affected by this treatment.

Twenty-eight oothecae were frozen between September 30 and October 19, 1945, in a refrigerator cooled by dry ice to temperatures ranging from −45 to −55°C. Seven of the oothecae were frozen in contact with moisture. In one case the whole ootheca was soaked in water for one day and in another case for three days; in all seven the outer lamellae were cut off just before freezing and the inner pod dipped in water. There was no change in undercooling points as a result of this treatment. Five oothecae were kept at 100% R. H. and room temperature for 14 to 20 days; again there was no change. All other oothecae were frozen dry and in all cases the run was made from room temperature in the same thermocouple holder. Excluding the data for the first five oothecae, in which the full range of undercooling was not obtained, a total of 545 undercooling points was recorded. Since these were not affected by age, contact moisture or storage conditions, they may be grouped as follows:

Table 1.
Distribution of undercooling points of *Mantis religiosa* eggs

Temperature range	Number	Undercooling points Percentage	Accumulative percentage
−24.0° to −24.95°C.	1	—	—
−25.0 to −25.95°C.	6	1	1
−26.0	5	1	2
−27.0	8	2	4
−28.0	12	2	6
−29.0	24	4	10
−30.0	36	6	16
−31.0	68	12	28
−32.0	46	8	36
−33.0	52	9	45
−34.0	45	8	53
−35.0	40	7	60
−36.0	41	7	67
−37.0	35	6	73
−38.0	30	5	78
−39.0	36	6	84
−40.0	33	6	90
−41.0 to −41.95°C.	27	5	95
Below −42.0°C.	*30	5	100
Total	575	100	—

*Estimated. The temperature scale was calibrated only to −42.0°C and the undercooling range of a few oothecae was not quite complete at this temperature.

DISCUSSION

Since the undercooling point of a *Mantis religiosa* egg is also its lower lethal temperature, the values in the last column of Table 1 may be used to determine the probable mortality of eggs exposed to any specific temperature in the undercooling range. If, for example, eggs are exposed to a temperature of −38.0°C., approximately 78% of them will freeze and die, while the remainder will be unharmed by such treatment. By obtaining records of minimum winter temperatures for an area where *M. religiosa* occurs, we can foretell with reasonable accuracy the mortality resulting from low tempeatures. There are, of

course, other lethal factors (James, 1944), but subzero temperatures are frequently dominant. Official weather records are not entirely suitable, as the microclimates of various oothecae may vary considerably. Snow cover, for example, would reduce the mortality greatly. Nevertheless an approximation can be made for a given area, and such a one has been worked out for the Belleville district. The official minimum winter temperatures listed in Table 2 are for the months of November to March, thus covering parts of two calendar years. They are duplicated in degrees Centigrade, and from these have been calculated the expected winter mortalities from freezing alone.

Table 2.

Minimum winter temperatures, observed and calculated mortalities of *Mantis religiosa* eggs at Belleville, Ontario, 1928-1946.

Winter of:	°F.	°C.	Observed	Calculated
1928-29	−17	−27.2	—	2
1929-30	−30	−34.4	—	48
1930-31	−22	−30.0	—	10
1931-32	− 1	−19.3	—	0
1932-33	−17	−27.2	—	2
1933-34	−39	−39.4	—	80
1934-35	−31	−35.0	—	53
1935-36	−19	−28.3	—	5
1936-37	−16	−26.7	—	2
1937-38	−22	−30.0	—	10
1938-39	−24	−31.1	—	17
1939-40	−20	−28.9	46.0	6
1940-41	−22	−30.0	15.6	10
1941-42	−30	−34.4	51.7	48
1942-43	−27	−32.8	45.7	34
1943-44	−16	−26.7	—	2
1944-45	−29	−33.9	45.1	44
1945-46	−21	−29.4	85.8	8

Reviewing the winter mortality at Belleville in the light of weather records and experimental results and observations, it appears that in some years low temperatures are the major factor. This is probably most true of those winters in which the temperature dropped farthest. In other years winter temperatures were not sufficiently low to cause substantial mortality, but other factors appeared which took considerable toll of the eggs. This happened in 1939-40 and 1945-46, when there was wide disagreement between expected and observed egg mortality. It should be noted that the calculated mortality never exceeded the observed mortality, indicating that factors other than low temperature are present but do not interfere with its action. Some evidence has already been secured which suggests that the percentage of spring hatch is largely dependent on the degree of embryonic growth during the previous fall. This is a point which requires further investigation.

CONCLUSIONS

From a study of the lower lethal temperatures of *M. religiosa* eggs and from observations made on winter mortality suffered by them in the Belleville, Ontario, area, it appears that while subzero temperatures take a toll of eggs proportional to the minimum winter temperature, there are additional factors which account for mortality previous to hatching time in June. These additional factors mask the relationship of mortality to low temperatures in nature but laboratory methods clearly demonstrate it.

SUMMARY

The undercooling points of *Mantis religiosa* eggs, which are also their lower lethal temperatures, fall in the range of approximately −24° to −43°C (−11° to −45°F.). Contact moisture appears to have no effect on the undercooling points, possibly because of the protection of the ootheca.

From November, 1928, to March, 1946, the minimum official winter temperatures at Belleville, Ontario, ranged from −19.3° to −39.4°C. (−1° to −39°F.). On the basis of these records, the calculated mortality of the eggs varied between 2 and 80 per cent.

From 1939 to 1946 records were taken of the mortality at the time of hatching, in June. These observed mortality values do not agree with the calculated values, but are invariably greater. This is taken to mean that other factors added their lethal effects to those of subzero temperatures.

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THE USE OF DDT IN CUTWORM CONTROL*

BY R. H. HANDFORD

Kamloops, B. C.

Seed growers at Grand Forks, B. C., on the suggestion of Henry Wiebe, Manager, Grand Forks Co-operative Growers' Exchange, used DDT as an emergency measure to control cutworms during the month of May, 1946, after supplies of bait ingredients had been exhausted in that district. The species involved were determined by K. M. King as *Euxoa ochrogaster* (Gn). with a few *E. tessellata* (Harr.), and other related species.

Mr. Wiebe brought this work to the attention of I. J. Ward, Provincial Entomologist, K. M. King of the Dominion Entomological Laboratory, Victoria, E. R. Buckell of the Kamloops laboratory and the writer when they visited Grand Forks on May 22. Preliminary observations, especially in a lettuce field in which 3 per cent dust had been applied at a rate of about 40 pounds per acre, suggested rather spectacular control and it was decided that the writer should remain in the district until May 27 to make somewhat more detailed observations.

In most instances a dust containing 3 per cent DDT had been used at rates varying approximately from 40 to 230 pounds per acre. A 50 per cent wettable material was used as a spray in one instance; another grower mixed some of this wettable dust with the 3 per cent dust to get 4 per cent DDT; and in several small gardens a dust containing 10 per cent DDT was applied.

In the majority of instances the mortality by May 27 appeared to have been little better than 50 per cent, the same or slightly higher than the average percentage mortality estimated for single applications of bait in that district. However, in addition to the lettuce field already mentioned, an onion field of John J. Semenoff, the first grower to use DDT in the Grand Forks district, gave evidence of fairly complete control. Similarly, observations and counts made from May 27 to June 1 by a grower, Peter de Wilde, on request, suggested very satisfactory results.

Semenoff had applied 3 per cent dust at an undetermined rate, probably over 50 pounds per acre, on a portion of a field showing considerable cutworm injury. In the remainder of the field he resorted to hand picking. The dust had been applied on or about May 10. On May 23 the stand of onions was much better on the dusted than on the hand-picked portion of the field, the difference in damage appearing in fairly sharp contrast along the exact edge of the dusted area. On that date no cutworms could be found in the dusted section but at the same time only a few were found in the remainder of the field. This suggested that the hand-picking had been fairly effective in removing the cutworms, although too slow to prevent marked injury.

*Contribution No. 2460, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Observations made up to May 27 on de Wilde's field of large seed onions indicated that approximately 60 per cent control had been secured by using 4 per cent dust at either 115 pounds per acre or 230 pounds per acre. Since an unprecedented cloudburst had occurred in the District May 25, de Wilde agreed to dust again on the evening of May 26. Thus on a few rows of the area previously covered at the rate of about 115 pounds per acre (4.6 pounds DDT) he applied more dust at the rate of about 200 pounds per acre, giving a total of about 12.6 pounds DDT per acre. He counted and removed dead from two sampling plots daily in these rows until June 1, at which time he sifted the soil of the plots. Only one living cutworm was found on the two plots, as compared with a total of 24 dead, this despite another heavy shower which had occurred the evening of May 27, 24 hours after the second application of the dust. Somewhat more surprising, but in keeping with the history of DDT, was the fact that he continued to find dead, on the plots dusted only once, on May 23. These, from May 27 to June 1, yielded a total of 14 dead and 2 living from the lighter (115 pounds) application and 15 dead and 8 living from the heavier (230 pounds) application, all in addition to the dead removed prior to May 27.

General dissatisfaction had been voiced with the degree of control obtained by the use of poisoned bait. This dissatisfaction was well-founded in some instances; in others it appeared that the growers had tended to underestimate the results.

Thus on the farm of R. C. Heaven, which had been heavily infested in 1945, fields baited prior to the emergence of the crop showed no cutworm damage and few cutworms could be found. In unbaited fields on the same farm, although damage was not very apparent, cutworms could be found much more easily. In another instance F. Pereverzoff had, by means of a heavy application of bait, greatly reduced the threat of cutworms that were migrating from a recently tilled alfalfa field into a crop of carrots. E. Atwood on the other hand had completely failed to get control by means of bait. In Atwood's field the soil had been loose and dry at the time the bait was applied; in that of Pereverzoff the soil was wet and hard from the heavy rain of May 25, a condition which usually forces the cutworms to travel above ground where they are the more likely to come in contact with the bait.

The observations were, of course, too few, continued over too short a period, and were insufficiently precise, to be relied upon fully. Most of the applications were too heavy and costly to be practical in crops other than those giving a high return per acre such as are grown at Grand Forks. However, the results do suggest that a thorough application of DDT dust will kill cutworms that appear above ground for too short a time to take bait, and that it holds its effectiveness much longer than the bait, thus helping to get away from the limitation of a night that is too cool for baiting. It may also be effective against climbing cutworms that spend very little time on the ground. Bait on the other hand should still find a place in controlling early stages and especially in clearing up infestations prior to the emergence of a crop. It will, moreover, remain the only practical chemical method of controlling infestations in crops having a low value per acre until the cost and rate of applications of DDT can be reduced. The results especially suggest that extensive, formal experiments should be conducted to determine the most effective, economical strength and rate of application, and the conditions under which satisfactory control may or may not be secured with DDT.

According to W. A. Luce, county agent for Yakima, Washington, quoted by Jack Jett in "Country Life", May, 1946, results with DDT have equalled those secured with bait for controlling cutworms in hop yards.

THE AGROTID GENUS *AGROTIPHILA* GRT. AND ITS GENOTYPE (LEPIDOPTERA) *

BY J. McDUNNOUGH,
Ottawa, Ont.

In 1875 (Ann. Lyc. Nat. Hist. N. Y. XI, 108) Grote erected the new genus *Agrotiphila*, based on a male specimen collected by Theo. Mead in Colorado and which he had determined as *montana* Morr. (1875, Ann. Lyc. Nat. Hist. N. Y. XI, 95). His characterization of the genus is as follows: "All the tibiae are spinose. The shape of the abdomen and habitus is as in *Anarta*. The eyes are naked, encroached upon by the caputal tegument, ovate, narrowed, fringed with lashes. the thorax is thickly and coarsely haired, without tufts. The maxillae are stout. The antennae are simple, thickly ciliate beneath in the male." Under the specific heading he notes that "my specimen, *numbered 28*, agrees very well with Mr. Morrison's description, except that the whitish *orbicular is open superiorly*, somewhat triangulate, and that the discal marks beneath and on the hind wings above are illegible." (The italics are mine).

Hampson (1903, Cat. Lep. Phal. Brit. Mus. IV, 133) evidently basing his conclusions on Grote's Colorado specimen, makes *montana* Morr. a synonym of *staudingeri* Moesch. and actually figures (as will be noted later) this Colorado specimen both in his text figure 47 and on Plate LIX, fig. 16, as Moeschler's species. In the same year Smith (Trans. Am. Ent. Soc. XXIX, 204) notes that the true type of *montana* was located in the Museum of Comparative Zoology at Cambridge and that the name *montana* would take priority over *rigida* Sm., a species with distinct frontal prominence for which Hampson had erected (*op. cit.*, 135) the genus *Orosagrotis*. In the Addenda to the same volume (p. 658) Hampson makes the change suggested by Smith without, however, apparently examining the frontal structure of Grote's specimen.

The matter rested thus until 1929 when Benjamin revised the whole group (Bull. Brook. Ent. Soc. XXIV, 172-176). Following his usual practice of basing a genotype *on a name* rather than on an *actual specimen* he designates *montana* Morr. as genotype of *Agrotiphila* Grt., sinks *Orosagrotis* Hamp. as a synonym, and creates the new genus *Agrotimorpha* for the species *without* frontal prominence, *viz.*, *staudingeri* Moesch., *maculata* Sm. and *colorado* Sm. He notes that "Grote's description of *Agrotiphila* is rather poor, as it omits mention of the front. It is not unlikely that he may have described the genus from a specimen of *colorado* erroneously determined as *montana* but he makes *montana* sole species and therefore genotype of *Agrotiphila*."

Recently in studying the matter I came to the conclusion that Grote's specimen of so-called *montana* could not possibly belong to this species on account of the *shape of the orbicular* which in the true *montana* and its synonym *rigida*, as well as in the allied species *incognita* Sm., is *small and round;* if. therefore, it could be shown that Hampson's figure, under *staudingeri*, of a Colorado male was based on Grote's original specimen No. 28, then this specimen could be definitely placed as *colorado* Sm. which possesses the open V-shaped orbicular. Correspondence with Mr. W. H. T. Tams of the British Museum, who was most helpful in supplying the required data, substantiated this surmise. Grote's specimen still exists in the British Museum and I have before me a photograph of same and of the labels it bears which are as follows: an oblong, bordered label with the name *Agrotiphila montana* Morr. in Grote's hand; a written label "28 Colo. Pl. return"; and a third label "Colorado, 12,000 ft. Grote Collection 84-54". The specimen is undoubtedly the one figured by Hampson as *staudingeri* and Mr. Tams has supplied the further information that the *front is smooth*. This, I believe, proves without doubt a misidentification on Grote's

*Contribution No. 2472, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

part and shows that *montana* Grt. (*nec* Morr.) should be known as *colorado* Smith which I propose to consider as the genotype of *Agrotiphila* Grt. *Agrotimorpha* Benj. will therefore fall as a synonym of *Agrotiphila* Grt. and *Orosagrotis* Hamp. must be resurrected for the species *montana* Morr. and *incognita* Sm. It seems most probable that the subgenus *Menada* Kozh. (1937, Fauna U.S.S.R., Vol. XIII (3), Argotinae, pp. 526, 593, 644, 651) with genotype *nomas* Ersch., will fall to *Orosagrotis;* the female genitalia of *incognita* Sm. are almost an exact match for Kozhantschikov's figure 305 of the genitalia of *nomas.*

While on this subject it might be noted that the more recently described *churchillensis* McD. (1932, Can. Ent. LXIV, 105) should be removed from *Agrotiphila* and placed in *Euxoa* near *colata* Grt. and its allies; since describing the species I have been able to examine the genitalia of a female of this species and find that the type of bursa and ductus seminalis is distinctly that of the *colata* group and not of the species now placed in *Orosagrotis.*

IVOR JESMOND WARD, 1908-1947

It is with deep regret that we record the death, at the age of 38 years, of Ivor Jesmond Ward, Provincial Entomologist for British Columbia, which occurred on February 5, 1947. Born in England, he came to Vernon, British Columbia, with his parents, 35 years ago. In 1926 he joined the staff of the Dominion Entomological Laboratory in Vernon, and after obtaining his Bachelor of Science degree in 1938 from the University of Alberta, he was employed continuously on field crop insect investigations in Vernon and Kamloops until, in 1943, he accepted the position of Provincial Entomologist.

With Ivor Ward's passing the Entomological Society of British Columbia loses a member and a friend, and the Provincial and Dominion Departments of Agriculture a valued worker. As Provincial Entomologist he might have had a long and valuable career, for few men have the ability for making friends better developed than did Ivor Ward, and he had a personality particularly suited to the field of extension entomology.

He will always be remembered by the stockmen of the British Columbian cattle ranges for the part he played in the study of their grasshopper problems, and in the organization of the grasshopper control zones.

After his appointment as Provincial Entomologist he had charge of the control work for the Colorado potato beetle, and was interested in devising better control methods for the various fruit, vegetable, and seed insects throughout the province, and in preparing provincial publications on insect control.

He is survived by his wife, formerly Marjorie Glover of Kamloops; his father, Fred Ward, of Vernon; and two sisters, Mrs. K. Burnham of Vernon and Mrs. Sid Walker of Vancouver.

E. R. Buckell.

ENTOMOLOGICAL SOCIETY OF BRITISH COLUMBIA

The 46th annual meeting of the Entomological Society of British Columbia which was held on March 15th, 1947, in the Brock Memorial Building, University of British Columbia, Vancouver, B. C., was one of the most successful in the history of the Society. More than 40 members and visitors attended, including three from the State of Washington. During the day 28 papers were presented, while an evening session was devoted to business, followed by the display of excellent kodachrome slides by J. D. Gregson and G. P. Holland. Twenty-six new members were accepted into the Society, bringing the total to over 100. Messrs. John Davidson and A. W. Finlay were elected to honorary life membership in appreciation of their longstanding and continued interest in our Society. Provision for this class of members was made in 1943 and others elected to it have been: Dr. W. R. Buckell, Messrs. W. Downes, J. W. Eastham, A. D. Heriot, L. E. Marmont and the late Messrs. A. W. Hanham and Max H. Ruhmann.

Mr. E. P. Venables was elected Honorary President. Other officers are: President, R. Glendenning; Vice-Presidents, H. Andison and J. D. Gregson; Hon. Secretary-Treasurer, W. G. Mathers; Assistant Secretary, G. P. Holland; Hon. Auditor, W. Baverstock; Advisory Board, G. P. Holland, J. Marshall, H. G. Fulton, V. E. L. Goddard, M. H. Hatch.

Volume 43 of our *Proceedings* was issued on February 4, 1947. It contains forty-six pages and includes a list of 773 species of Lepidoptera from the Shuswap Lake District, B. C.

W. G. Mathers

BOOK NOTICE

THE BUTTERFLIES OF WASHINGTON

By Ben V. Leighton. University of Washington Publications in Biology, vol. 9, no. 2, pp. 47-63. November, 1946. (University of Washington Press, Seattle, Washington. Forty-five cents).

This annotated list records 143 species and 81 subspecies of Rhopalocera occurring in the state of Washington. The scientific name of each species is given. This is followed by the common name, a reference to a published figure, usually that in Holland's *Butterfly Book*, and the localities where specimens have been captured. These localities are cited alphabetically under "eastern" and "western" Washington and each is followed with letters enclosed in parentheses to indicate the collection containing the recorded specimen.

The introductory part includes a short account of the general time of flight of the major families or subfamilies, notes pertaining to a few species of economic significance, as well as suggestions as to the best collecting areas. An alphabetical list of the location and elevation of unfamiliar localities is also given.

The arrangement of species follows that of the 1938 McDunnough *Check List* but the designation of populations of subspecific rank merely as "var." is disappointing. This term has been so loosely applied in the past, that it has lost any definite meaning and its use should be discontinued in entomological nomenclature. Leighton's rare departure from this unfortunate term occurs on page 61. There, the reference to *spangelatus* Burdick as a "race" of *Plebeius lupini* Bdv. is much more informative.

The list is to be used in conjunction with Holland's *Butterfly Book* and it will be of considerable assistance to anyone collecting or recording the butterflies or skippers of Washington.

T. N. Freeman

GUELPH PRINTING SERVICE
Mailed Friday, June 20, 1947.